ORTHOMETRIC PROCESSING OF VERY HIGH SPATIAL RESOLUTION FRAME IMAGERY USING DISTRIBUTED TECHNIQUES

R.L. Fischer, J.G. Ruby, M.J. Pierson, J.C. Eichholz, E.B. Zimmerman
U.S. Army Corps of Engineers, Engineer Research and Development Center
Topographic Engineering Center
Alexandria, VA, 22315

X. Sun, D. Florence
Flight Landata Incorporated
Lawrence, MA, 01843

ABSTRACT

Very high spatial resolution frame imagery (pixel areas << 1.0 m^2) is becoming readily available from a number of government-owned and commercial sensors. These systems have and will be mounted on a variety of rotary and fixed-wing aircraft, and because of their small size, are ideally suited as organic sensors for Unmanned Aerial Vehicle (UAV) platforms. Because of the relatively small ground coverage of these systems, a large number of individual frames must be quickly and accurately georegistered to cover a typical area of interest. In a test conducted at Yuma, AZ during February 2004, a total of 88 frames of stereo imagery with 0.01 m^2 spatial resolution were used to cover approximately 4 km along a roadway. Using a recently developed distributed processing system, the 88 frames were mosaicked and georegistered to meter level accuracy in less than 52 minutes. Incorporating state-of-the art hardware, the same number of frames could be used to cover more than 20 km on the ground, providing a valuable data source to multiple applications including targeting, route reconnaissance, and improvised explosive device (IED) detection.

1. INTRODUCTION

Products derived from very high spatial resolution imagery have a multitude of tactical applications which allow the battlefield to be viewed in greater clarity, a key requirement of the Future Force. These applications include stereo vision, site mapping, battlefield reconnaissance, targeting, and improvised explosive device (IED) detection. However, a critical step in effectively utilizing this data are the accurate georegistration of the imagery to a pertinent ground coordinate system.

To satisfy the particular objective of creating orthometrically accurate mosaics in near-real-time, a distributed, photogrammetric pre-processing technique was developed. The most laborious and time-consuming task associated with orthoregistration is the selection of tie points (image to image) and ground control points (image to geographic coordinates). The selection of control points using traditional techniques can take hours or days for even a moderate number of individual images. However, because the determination of tie points between two (or more) overlapping frames can be considered independent from other sets of overlapping frames, an automated parallel or distributed approach can be used.

2. METHODS

As part of this effort, an existing hardware and software suite was quickly modified by the Corps and Flight Landata Inc. as a proof-of-concept for the identification of IEDs using high spatial resolution change detection (pixel area = 0.01 m^2). The sensor system consisted of four 1392 x 1040, 10 bit, progressive scan cameras filtered to blue, green, red, and near-infrared bandpasses. Imagery was collected via a Piper Cherokee 6 at 1500 feet above ground level to achieve the required spatial resolution from the 25 mm focal length lenses. The sensor position during exposure was determined using Wide Area Augmentation System (WAAS) GPS. Sensor orientation was derived from onboard accelerometers and fiber optic gyros. Overlap between individual frames was approximately 80 percent.

The developed processing technique computes an initial frame exposure position and orientation of all frames collected. Each combination of overlapping frames (up to a total of 6 frames per tie point) is then packaged and parsed by a root machine to the individual processors. The individual processors calculate a user defined, or software suggested number of tie points, and return the completed points to the root machine. Results from the individual processors are tabulated and translated into sensor model support files. The above steps are repeated using a preexisting registered source to determine ground control points. Potential reference sources include, but are not limited to, IKONOS, Quickbird, controlled image base (CIB), U.S. Geological Survey (USGS) digital orthophoto quarter quads (DOQQs), and National Assets. Tabulated tie and ground control points are then processed through a co-

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **00 DEC 2004**	2. REPORT TYPE **N/A**	3. DATES COVERED **-**
4. TITLE AND SUBTITLE **Orthometric Processing of Very High Spatial Resolution Frame Imagery using Distributed Techniques**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **U.S. Army Corps of Engineers, Engineer Research and Development Center Topographic Engineering Center Alexandria, VA 22315; Flight Landata Incorporated Lawrence, MA 01843**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM001736, Proceedings for the Army Science Conference (24th) Held on 29 November - 2 December 2004 in Orlando, Florida., The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**2**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

linearity-based bundle block adjustment (Slama, 1980) using commercial-off-the-shelf (COTS) software to determine an accurate position and orientation of each frame exposure station. Construction of image-based end products, such as high spatial resolution stereo models, digital terrain models, and mosaics is then straightforward.

3. RESULTS

For the 88 frames of the Yuma imagery, 1343 tie and ground control points were calculated in approximately seven minutes using a dedicated 32-node processing system. Bundle adjustment and mosaic construction using the COTS software package SOCET SET took an additional 45 minutes. A USGS DOQQ was used as the geographic reference source. Final spatial accuracy (elliptical error) of the bundle adjustment was 2.5 m. Data were collected on two subsequent dates (Feb. 11 and Feb. 12) to demonstrate the change detection concept. An example of the 0.01 m^2 spatial resolution image mosaic is shown in Figure 1.

Manual comparisons between imagery collected on subsequent days over the Yuma site showed these data could successfully locate IED-like items. Pixel level co-registration between the two days allowed an analyst to locate changes with minimal user fatigue. An example of a simulated IED found through change detection is shown in Figure 2. The Feb. 11 imagery (before IED placement) is shown on the left side of Figure 2, the Feb. 12 imagery (after IED placement) on the right. Changes between the two dates are obvious. The break in the curb on Feb. 11 has been filled in by a bright material, and a "drag" line leading away from the curb is readily apparent. Six additional items of similar size were found throughout the 4 km roadway.

4. CONCLUSIONS

Results from numerical simulations and actual imagery demonstrates the capability to georegister long, high spatial resolution flightlines quickly and accurately. Imagery collected during February 2004 test in Yuma show that the concept of change detection was successful in locating simulated IED devices in the field. While the identification of IEDs at Yuma was performed manually, the ability to co-register two sets of imagery acquired at different times accurately will make it possible to effectively use digital or automated change detection routines. Further hardware and software improvements will enable future systems to produce products over larger areas in less time, providing a valuable data source to multiple tactical and civil applications.

4. REFERENCES

Slama, C.C. (Editor), 1980. Manual of Photogrammetry. American Society of Photogrammetry, 1056 pp.

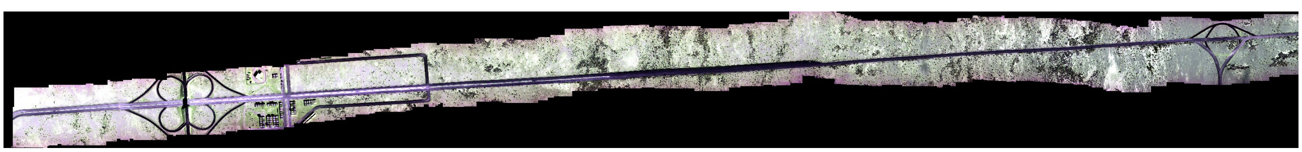

Figure 1. True color mosaic of Yuma roadway from Feb. 11, 2004.

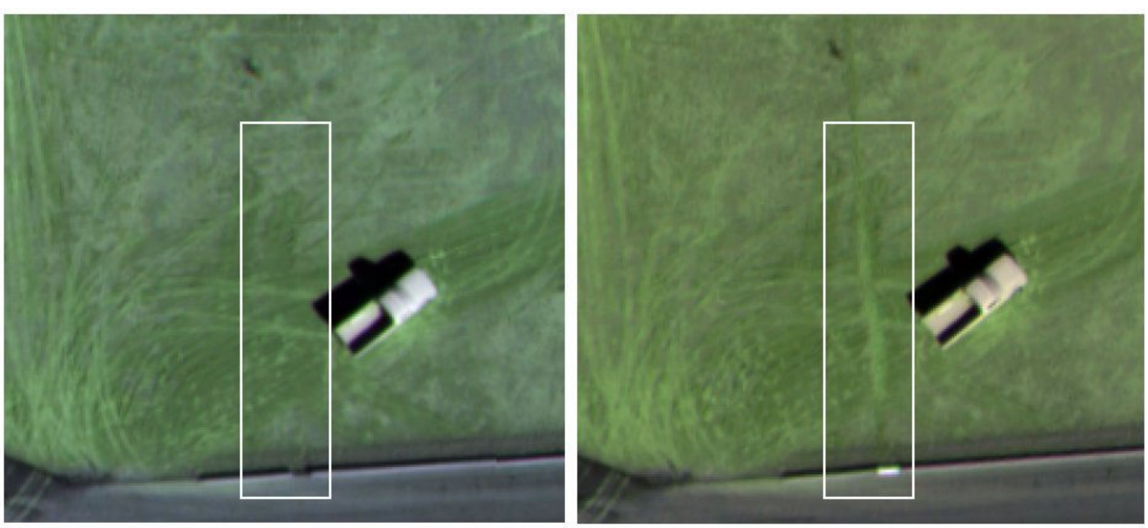

Figure 2. Before (Feb. 11) and after (Feb 12.) placement of a simulated IED device.